Aglime Terms[1]

ACID FORMING FERTILIZER[5] **-** A fertilizer that is capable of lowering the pH (increasing the acidity) of the soil following application.

Ammonium Nitrate (NH_4N0_3): the most common N fertilizer available today

Anhydrous Ammonia (NH_3): rapid change of NH_3 to NH_4^+ ; so it is considered an acid forming fertilizer.

Ammonium Sulfate $(NH_4)SO_4$; warm season fertilizer contains a good sulfur supply

Urea: synthetic organic source of N. 45 to 46 % N. The nitrogen is in the NH_2 form when applied but will quickly convert to NH_4, so it is considered an ammonium fertilizer.

NH_4^+ and $N0_3^-$ forms of N are both plant available.

- The $N0_3^-$ form is easily taken up by the plant.
- Microorganism convert NH_4^+ to $N0_3^-$: nitrification.

Nitrogen fertilizer may be non-acid forming. This means that they do not contain NH_4^+ (ammonium) or that limestone has been added to neutralize the H released during Nitrification. Acid forming fertilizers are not a problem as long as the soil manager soil tests regularly. The acidity released by these fertilizers may be corrected for with liming. (See also Page 2 of FG 52, “Fertilizer and Lime Materials” of Oregon State University, Extension).

ACID EFFECTED SOILS[6] Plants grown in acid soils can experience a variety of symptoms including Al, H, and/or Mn toxicity, as well as potential nutrient deficiencies of Ca and Mg. Al toxicity is the most widespread problem in acid soils. Al is present in all soils, but dissolved Al^{3+} is toxic to plants; Al^{3+} is most soluble at low pH, above pH 5.2 little aluminum is in soluble form in most soils. Al is not a plant nutrient, and as such, is not actively taken up by the plants, but enters plant roots passively through osmosis. Al damages roots in several ways: In root tips Al interferes with the uptake of Ca, an essential nutrient, as well as binds with phosphate and interferes with production of ATP and DNA, both of which contain phosphate. Al can also restrict cell wall expansion causing roots to become stunted.

Below pH 4, H^+ ions themselves damage root cell membranes.

In soils with high content of Manganese (Mn) containing minerals, Mn toxicity can become a problem at pH 5.6 and below. Mn, like aluminum becomes increasingly more soluble as pH drops, and Mn toxicity symptoms can be seen at pH's below 5.6. Mn is an essential plant nutrient, so plants transport Mn into leaves. Classic symptoms of Mn toxicity are crinkling or cupping of leaves.

Agricultural Amendments and Agricultural Minerals - the difference between the two according to Oregon Department of Agriculture (ODA):

Oregon Department of Agriculture defines:

Agriculture Amendments

Definition of an agricultural amendment based on ODA, it is a mixed or unmixed synthetic chemical substance, a chemically or physically modified natural substance, a naturally occurring substance or a manufacturing by-product, or a combination of those substances or by-products, intended to induce crop yields or plant growth or to produce any physical, microbial or chemical change in the soil. It does NOT mean: fertilizer products, agricultural mineral products, lime products, hays, straws, peat, leaf mold, sands, expanded silicates, biosolids-derived products, compost and animal or vegetable manures that are not packaged and don not contain a grade statement or guaranteed analysis.

On the ODA tonnage summary agricultural amendments are listed as Zeolite, Surfactants, Biological Inoculum, Polyacrylamid, Humic acid, Calcined clay, and other agricultural amendments.

Agricultural Minerals are by definition a mineral substance, mixture of mineral substances or mixture of mineral and organic substances containing less than five percent of total nitrogen (N), available phosphate (P_2O_5) or soluble potash (K_2O), singly, collectively or in combination, designed for use principally as a source of plant food, in inducing increased crop yields or plant growth or producing any physical, microbial or chemical change in the soil. It does NOT mean: fertilizer products, agricultural amendment products, lime products, sand, soil, biosolids-derived products, compost and animal or vegetable manures that are not packaged and don not contain a grade statement or guaranteed analysis.

On the Oregon tonnage summary agricultural minerals are listed as boron, calcium, copper, gypsum, iron, magnesium, manganese, molybdenum, sulfur, trace combinations and zinc.

Lime is defined as any substance or mixture of substances having calcium or magnesium compounds capable of neutralizing soil acidity.

On the Oregon tonnage summary liming materials are listed as calcium hydroxide (hydrate), standard dolomite, standard calcite, by-product lime, and liming materials-other analysis.

AGRICULTURAL LIMING MATERIAL - Any material that contains calcium, or calcium - magnesium in forms that are capable of reducing soil acidity.

AGRICULTURAL LIMESTONE [2]– Finely ground or crushed limestone, either calcitic or dolomitic.

CALCITE - The crystalline (having the regular internal arrangement of atoms, ions or molecules characteristic of crystals) form of calcium carbonate. Pure calcite contains 100% calcium carbonate (40% calcium Ca). Calcite can be may be colorless, but is usually tinted by impurities.

CALCITIC LIMESTONE - A widely used term that refers to agricultural limestone with a high calcium content. Contains mainly calcium carbonate, but may also contain small amounts of magnesium. There are no regulations or restrictions governing the calcium or magnesium content. 5 to 200 million years old, mostly Jurassic and Cretaceous.

CALCIUM (Ca) - Occurs in nature only in combination with other elements, does not occur solely as calcium. One of the 16 essential plant nutrients. It along with magnesium is one of the two main ingredients in limestone. Calcium is an essential part of teeth, bone and shells.

CALCIUM CARBONATE (CaCO3) - A compound which contains calcium combined with carbonate. It occurs in nature as limestone, marble, chalk, marl, shells, and similar substances.

CALCIUM CARBONATE EQUIVALENT (CCE) - Expression of the acid-neutralizing capacity of a carbonate rock relative to that of pure calcium carbonate (e.g. calcite). It is expressed as a percentage. For pure calcite the value is 100%, pure dolomite the value is 108.5%. Actual CCE of most limestone will vary from these percentages due to impurities in the rock, and the fact that most commercially available limestone materials have a mixture of calcite and dolomite rather than either in its pure form.

The expression of neutralizing capacity "CCE" does not reflect true reactivity action of natural limestone. Pure dolomites show a CCE of 108.5% - however, availability of such neutralizing capacity requires very strong soil acidity and the calcium carbonate component of dolomitic limestone reacts faster than the magnesium carbonate.

CALCIUM OXIDE (Ca0) - Chemical compound containing calcium and oxygen. Calcium oxide does not occur in nature, it is formed from calcium carbonate by heating limestone to drive off the carbon dioxide.

CALCIUM OXIDE EQUIVALENT - The percentage of calcium oxide in a liming material plus 1.39 times the magnesium oxide content. For pure calcite, the value is 56.0%, for pure dolomite the value is 60.8%. Used by some states as a measure of aglime quality.

CHALK – (CaCO3) - is a soft, white, porous sedimentary form of limestone composed of the mineral calcite which is calcium carbonate ($CaCO_3$). It forms under reasonably deep marine conditions from the gradual accumulation of minute calcitic plates (coccoliths) which are shed from micro-organisms called coccolithophores. 80 to 90

million years old - Cretaceous Period.

DOLOMITE – MgCO3 - Limestone that contains magnesium carbonate (MgCO3) in an amount *approximately equivalent* to the calcium carbonate content in the stone. Limestone containing magnesium carbonate in lesser proportions is referred to as magnesium limestone or Dolomitic limestone **$CaMg(CO_3)_2$** . Pure dolomite is 54.3% CaCO3 and 45.7% MgCO3 or expressed another way, is composed of 30.4% CaO, 21.8% magnesia (MgO), and 47.3% CO3.

DOLOMITIC LIMESTONE - $CaMg(CO_3)^2$ Limestone that contains from 10%, but less than, 50% dolomite, and from 50-90% calcite. The MgCO3 content of Dolomitic limestone may range approximately from 4.4-22.6%. 200 to 250 million years old, Triassic.

EFFECTIVE CALCIUM CARBONATE EQUIVALENT - (ECCE) An expression of aglime effectiveness based on the **combined** effect of **chemical purity (CCE**) and **fineness**. It is required for labeling purposes in some states. Determined by multiplying CCE by a set of factors based on the fineness of grind of the limestone. Also referred to as effective neutralizing value (ENV), total neutralizing power (TNP), effective neutralizing material (ENM) and, in one state, as the "lime score".

This expression of neutralizing capacity combined with effectiveness (ECCE) does not reflect true reactivity action of natural limestone. The effectiveness of limestone - based on the various methods used – provides different values of effectiveness given by particle size (see below: ENM). While this method considers particle size in addition to the equivalent (CCE), different methods use different values for effectiveness.

EFFECTIVE NEUTRALIZING POWER (ENP) - This is a term used in Ohio. It means the neutralizing value of liming material base on the ECCE (effective calcium carbonate equivalent expressed as a dry weight. It is used to take into account for the amount of moisture (water, etc) that maybe present in liming materials.
This expression of neutralizing capacity does not reflect true reactivity action of natural limestone.

Effective Neutralizing Material (ENM) [2] – (taken from Missouri Liming Laws) The pounds of effective neutralizing material in one ton of agricultural lime based on the calcium carbonate equivalent of the agricultural liming materials as delivered for sale and the fineness factor calculated from the percent of materials passing a United States standard sieve size number eight and remaining on a United States standard sieve number sixty (60), and percent of materials passing a United States standard sieve size number sixty (60).

United States Standard Sieve Size No. Ranges	Efficiency Percentages %
% Remaining on 8	0
%Passing 8 and Remaining on 40	25
%Passing 40 and Remaining on 60	60
%Passing 60	100

The fineness factor is calculated to allow for variations in fineness of materials using the following formula:

Fineness Factor = (% of materials passing U.S. No. 8 and remaining on 40 x 0.25) + (% of materials passing U.S. No. 40 and remaining on 60 x 0.60) = (% of materials passing U.S. No. 60 x 1.00)

Calculations to allow for variations in calcium carbonate equivalent and fineness shall be made by using the following formula:

$$E.N.M. = \frac{\%\ CCE}{100} \times \frac{\text{Fineness Factor}}{100} \times 800$$

The final result of calculations shall be rounded to nearest whole number, which will be pounds of effective neutralizing material per ton.

This expression of neutralizing capacity does not reflect true reactivity action of natural limestone. The effectiveness of limestone - based on the various methods used – provides different values of effectiveness given by particle size (see ENM). While this method considers particle size in addition to the equivalent (CCE), different methods use different values for effectiveness. It is not clear who and how it was determined that ALL limestone materials passing a #60 mesh screen should be 100% effective.

EFFECTIVE NEUTRALIZING VALUE[3] - (ENV) The combination of TNV and reaction rate is the effective neutralizing value (ENV) of the lime. “Different agricultural liming materials have different values. The value of agricultural limestone varies with the geological source of the limestone and how the limestone is processed. The geological source of the limestone determines how much calcium carbonate and magnesium carbonate is in a ton of lime. The amount of these two carbonates determines the total neutralizing value (TNV) of the limestone. The processing of the limestone determines the fineness of the particles in the finished product. The lime's fineness determines how fast the limestone will react with the acids in the soil to increase the soil pH. The combination of TNV and reaction rate is the effective neutralizing value (ENV) of the lime.

Fineness of a ground limestone (sieve size) determines how fast the lime reacts with an acid. As a ton of limestone is ground finer there is more surface area. This increased surface area gives more places where the lime can react with the acids in the soil. The fineness of limestone is measured by how much will pass through different mesh

screens or sieves. The screen mesh or sieve size is the number of wires in a 1-inch/length of screen. The larger the number of the mesh means the more wires per inch which results in smaller holes in the sieve. Soil and management conditions will affect how fast the different particle sizes react with your soil. However, based on plant response and laboratory studies we can expect the following to occur when lime is worked into the soil:

1. particles that pass a 100-mesh sieve react 100 percent with the soil in six months or less; 2. particles that pass a 60-mesh or finer sieve react 100 percent within the first year; 3. particles that pass a 20-mesh but not a 60-mesh sieve react about 50 percent in the first year; 4. particles not passing a 20-mesh sieve have little liming value and are not generally credited when evaluating lime materials.

Effective neutralizing value (ENV) is a way of combining TNV and fineness to estimate how much of a liming material will be available to change the soil pH within one year.

Three pieces of information are needed to calculate a ground limestone's ENV; these are its TNV in percent CCE, the percent of the limestone that passes a 20-mesh sieve, and the percent that passes a 60-mesh sieve. The percent of limestone that passes a 60-mesh sieve is given a weighting value of 1.0 since it is considered to be completely available within one year. The amount passing a 20-mesh sieve but not a 60-mesh sieve (subtract that passing a 60-mesh sieve from that passing a 20-mesh sieve) is given a weighting value of 0.5 since only half of it is available in the first year. Multiply these weighting values by the percent material in the respective sieve class. Next add these values to get the "% Effectiveness of liming material". Divide this value by 100 to convert the number to a decimal fraction. This decimal is then multiplied by the "Calcium Carbonate Equivalent" to get the "Effective Neutralizing Value (ENV) of the liming material" or "% ENV."

Again, this expression of neutralizing capacity is based on CCE and particle size. Here material passing a 100 mesh screen are considered 100 percent reactive within 6 months - not considering potential slower reactivity of various materials and not considering the fast reactivity of limestone materials with particle sizes below 200 mesh.

FINENESS FACTOR[4] – Term used in Oregon. The fineness factor is related to the particle size of a liming material. The particle size affects the rate at which a liming material goes into solution in the soil. Lime does not neutralize acidity or release its nutrients until it has dissolved, so fine particles will react rapidly if sufficiently mixed with the soil.

FINENESS INDEX - The percentage by weight of a liming material that will pass designated sieves. It is calculated to account for particle distribution by totaling the amounts of material that are held and /or passed through the various sieve screens as determined by various state liming regulations and guidelines.

FLUID-BED ASH - Byproduct of electrical utility companies from mixing limestone into ground coal in a fluidizing bed to control burning rates of coal. The ash remaining after burning the coal has a neutralizing value for correcting soil acidity. Ashes and dusts collected from smoke stacks also can neutralize soil acidity. The calcium carbonate equivalence can vary widely from these sources and should be determined by laboratory analysis. Application rates need to be adjusted for the relative neutralizing value of these materials. Not permitted in all states. Heavy metal contents must be evaluated, soil load calculated and considered.

FLUID LIME - Also known as "liquid lime". This product is made by mixing very finely ground limestone (as a minimum: 100% passing a 100 mesh sieve and 89-90% passing a 200 mesh sieve) with either water or liquid nitrogen fertilizer along with a suspending agent (attapulgite clay or other) and applying with a liquid fertilizer applicator.

GYPSUM - A hydrated form of calcium sulfate **(CaSO4)**. It supplies calcium to the soil, but it is a neutral substance and does not correct soil acidity; therefore it is not a liming material. The main sources of calcium sulfate are naturally occurring Gypsum : Calcium sulfate Dihydrate ($CaSO_4 \cdot 2H_2O$) and Anhydrous Calcium Sulfate (CaSO4).

1. **Gypsum Dihydrate** – (**$CaSO_4 \cdot 2H_2O$)** a very soft mineral composed of calcium sulfate dihydrate. Very reactive.
2. **Gypsum Anhydrite** (**CaSO4)** is the most frequently found deposits of gypsum. Its solubility in saline soil solutions is also strongly dependent on NaCl concentration.

HYDRATED LIME – $Ca(OH)_2$ = slaked lime, calcium hydroxide Produced by adding water to burned lime or by absorption of moisture from the air. It has the same characteristics and limitations as burned lime.

LIME – (Defined by Oregon Department of Agriculture) – Any substance or mixture of substances having calcium or magnesium compounds capable of neutralizing soil acidity.

LIME – CaO - Chemically it is calcium and maybe some magnesium oxide. Produced by high temperature heating calcitic or Dolomitic limestone, which will replace the carbonate ion (CO3--) of the limestone with oxygen. However, the term “LIME” is broadly applied in agriculture to any material containing calcium and magnesium in forms capable of correcting soil acidity.

LIME REQUIREMENT - The amount of agricultural limestone required to move the soil acidity to reach another degree of acidity or pH. The desired pH range will depend on if the crop is an acid loving or more alkaline loving crop. It is usually expressed in pounds per acre of CaCO3 needed to bring the soil to the desired pH under field conditions.

LIME SCORE[4] – This is a term used in Oregon. The lime score of a liming material is a numerical expression of the quality of the lime using fineness factor, calcium carbonate equivalent and moisture factor. CCE x Oregon's fineness factor x Oregon's moisture factor.

This expression of Lime Effectiveness does not reflect true reactivity action of natural limestone.

LIME SLUDGES - Some water softening plants have lime sludge containing fine lime particles that are precipitated in the softening process. Lime sludges vary in calcium carbonate equivalent (CCE) and water content, both of which would influence the amount of sludge, needed to equal dry aglime.

MAGNESIAN LIMESTONE - Limestone that contains 5-10% pure dolomite, and 90 - 95% calcite. The MgCO3 content of magnesian limestone range from 2.3-4.4%.

MAGNESIUM CARBONATE - A compound consisting of magnesium combined with carbonate. It occurs in nature as the mineral magnesite and as an essential part of Dolomitic limestone and dolomite. Magnesite is extremely hard.

MAGNESIUM OXIDE (MgO) - The chemical compound composed of magnesium and oxygen. It is formed from MgCO3 by heating to drive off the carbon dioxide, or in mixture with CaO by heating magnesian limestone or dolomite. Also known as magnesia, it occurs in nature as periclase.

MARBLE - A compact, hard, polish-able form of limestone. 420 to 200 million years old.

MARL - A granular or loosely consolidated, earthly material composed largely of calcium carbonate as seashell fragments. It contains varying amounts of silt and organic matter.

MECHANICAL ANALYSIS - Also referred to as screen or sieve analysis. Indicates the percentages of a material that fall within predetermined particle size limits and between certain mesh sizes. State laws governing aglime quality standards are all based on particle size distribution guidelines established by mechanical analysis.

MOISTURE FACTOR[4] – Term used in Oregon. As water does not reduce acidity, the acid neutralizing value of a liming material decreases on a weight basis as the moisture content increases. Moisture factor =100 - % water in lime / 100.

PELLETIZED LIME - Limestone which is granulated into a pellet. The original product is a finely ground limestone (usually 100-mesh, better if smaller) in size that is put into granulation equipment and bound together with a highly water-soluble substance. This process improves the handling and application of liming materials. In regards to correcting soil acidity, it takes the same amount of effective calcium carbonate

equivalent pelletized lime as it does any other liming material to achieve correction of soil acidity. Pelletized lime should ideally be applied onto the soil surface and watered in. Only after that, should soil be turned. However, pelletized lime can be successfully precision placed in direct seed applications.

pH (pondus hydrongenii) - The negative logarithm of the hydrogen ion activity of a soil. The measurement of the degree of acidity or alkalinity of a soil.

SLAGS - One of the steel industry byproducts is magnesium or calcium silicate or slag. Air-cooled slags must be ground the same as limestone. Water cooled slag is a porous granular material produced when water is applied to the hot slag. Because of the large particles associated with this material, it usually requires screening.

SMP Buffer Shoemaker, McLean, and Pratt buffer method to determine the lime requirement of a soil. Defined as: " the amount of limestone or other bases which when incorporated within a given depth of acid soil increases the pH to some selected level". The SMP buffer was developed for soils having a relatively high lime requirement and significant reserves of exchangeable Al. The SMP buffer is suited for soils having large amounts of clay and high organic matter content. The majority of laboratories in the Midwest and on the West Coast use the SMP buffer. The SMP is not well suited for low exchange capacity soils and can give inaccurate results on these soils. SMP is expressed in Calcium Carbonate equivalent in tons per acre of plowed soil to a depth of 8 inches; crop and regional specific adjustments are common.

SOIL ACIDITY Acidity in soils comes from H^+ and Al^{3+} ions in the soil solution, sorbed to soil surfaces. While pH is the measure of H^+ in solution, Al^{3+} function is important to understand in acid soils because between pH 4 and 6, Al^{3+} reacts with water (H_2O) forming $AlOH^{2+}$, and $Al(OH)_2^+$, releasing extra H^+ ions. Every Al^{3+} ion can create 3 H^+ ions. Many other processes contribute to the formation of acid soils including rainfall, fertilizer use, plant root activity and the weathering of primary and secondary soil minerals. Acid soils can also be caused by pollutants such as acid rain.

SOIL BASICITY Basic soils have a high saturation of base cations (K^+, Ca^{2+}, Mg^{2+} and Na+). This is due to an accumulation of soluble salts in soils which are classified as either saline soils, sodic soils, saline-sodic soil or alkaline soils. All saline and sodic soils have high salt concentrations, with saline soils being dominated by Ca and Mg salts and sodic soils being dominated by Na. Alkaline soils are characterized by the presence of carbonates.

SOIL pH - An expression of the degree of acidity or alkalinity of a soil, measured on scale of 1 to 14. Readings from 1.0 to 6.9 indicate that a soil is acid (sour); from 7.1 to 14.0 that it is alkaline (sweet). A reading of 7.0 is neutral. The term "pH" refers to negative logarithm (p) of the hydrogen ion (H) concentration in soil solution.

Soil pH Measurement [7], METHOD / Example1 : Water 1:1 H2O - The pH is determined using a glass and reference electrode with a pH meter on a 1:1 suspension

(5 gram scoop of soil to 5 milliliters water). Samples of mineral soils with pH values of less than 6.0 are analyzed further for the following lime requirement test. The SMP Buffer Index (lime requirement test) is determined by adding 10 milliliters of buffer solution to the above 1:1 sample. The Buffer Index of the suspension is determined with a pH meter, after the sample has been stirred intermittently for 15 minutes.

1:1 H_2O is a mixture, by weight, of one part soil to one part distilled H_2O. It is the method most commonly used in the field because of the availability of water.

Seasonal variations in soil pH can be detected with the 1:1 H_2O method; therefore, it is not used to determine reaction classes in USDA *Soil Taxonomy*. If pH varies widely, knowledge of this variability is important because of the effect of pH on crop performance and on some other aspects of land use.

Soil pH Measurement, METHOD / Example 2 : Calcium Chloride

1:2 0.01 M $CaCl_2$ is a mixture, by weight, of one part soil to two parts 0.01 M $CaCl_2$ solution. Calcium chloride ($CaCl_2$) pH is the standard used in *Soil Taxonomy* to differentiate acid and nonacid family reaction classes in mineral soils and euic and dysic family classes in organic soils. The 0.01 M $CaCl_2$ solution dampens the seasonal variation in soil pH by providing Ca^{2+} ions that displace the hydronium and aluminum ions from the colloid surfaces. The result is a pH measurement that remains somewhat invariable to the seasonal changes in pH. The use of the $CaCl_2$ solution also diminishes the seasonal effect of soluble salt concentration.

Regardless of the method used, increasing dilution (within limits) will raise the pH. The more dilute the soil : water ratio, the higher the measured pH. For example, a 1:1 H_2O pH is generally lower than 1:10 H_2O pH.

SOIL REACTION - The acidity or alkalinity status of a soil. Soils that are acid are said to have an acid reaction; those that are alkaline, an alkaline reaction.

TOTAL NEUTRALIZING VALUE[3] - The total neutralizing value (TNV) is the percentage of the limestone capable of neutralizing an acid and is expressed as CCE. If a limestone has a TNV of 80 percent it means that 1 pound of it will neutralize the same amount of acid as 0.8 pounds of pure calcium carbonate. Limestones differ in TNV since they all contain impurities which do not react with acid; the more impurities the lower the TNV. Also some limestones contain magnesium carbonate, which has a greater neutralizing value than calcium carbonate per unit of weight. One pound of pure magnesium carbonate will neutralize the same amount of acid as 1.2 pounds of calcium carbonate. Therefore, dolomite limestone (also called high magnesium lime) often has a higher TNV than calcium limestone. Since limestone never has more magnesium than calcium carbonate, the highest purity of dolomite limestone has a TNV of about 108 percent. Hydrated and slaked lime are heated to drive off carbon dioxide, leaving oxide forms of calcium and magnesium. These have higher TNVs than ground limestone.

This expression of neutralizing capacity does not reflect true reactivity action of natural limestone. All above mentioned methods are an effort to express effectiveness of limestone – be it chemically and/or effectiveness supposedly correlated to a given particle size.. However, in laboratory studies and practical field applications we find different results.

Just as natural finely pulverized limestone has replaced the use of highly caustic burnt and hydrated lime of the past, today's new ultra fine grinding technology provide modern limestone materials of far better effectiveness than current laboratory methods of assessment can express.

Realize that discrepancies exist and become comfortable in making decisions based on best information given – no matter how inconclusive. But better be able to defend your choice when limestone of the past no longer satisfies the grower's needs because highly reactive modern materials outperform economically as well as in their effectiveness!

Important Findings

Limestone effectiveness depends on:

- ***Physico-chemical characteristics***
- ***Particle size***
- ***pH of soil and pH goal***
- ***Sufficient lime distribution in soil including strategic placement***
- ***Effectiveness depends on reactivity***
- ***Lime Score, ECCE, ENM, TNV, ENP, ENV etc. are not transferable from lime to lime***
- ***Reactivity improves assessment of effectiveness***
- ***Results of dissolution are confirmed by soil tests and field trials.[8]***

Advice for liming based on reactivity:

Heavy Soils: require highly reactive limes to reach neutral reaction.

Sandy Loam Soils: increasing your pH goals requires increasingly higher amounts of low reacting dolomites compared to small amounts of highly reactive calcites.

Sandy, Organic Soils, Pastures: slower reacting limes with magnesium from dolomites. Using highly reactive limes requires using only small amounts often.

Forest: use slow reacting dolomites or small amounts of reactive lime plus K-mag.

Substrates: highly reacting components are needed to reach pH goal fast and slower reacting component for later supply. Use a broad spectrum particle size calcitic lime for best results.

Sources:

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[2]Missouri Agricultural Liming Materials Law and Rules

[3]Ed Rayburn, The Value of Agricultural Limestone, http://www.wvu.edu/~agexten/forglvst/valuelime.htm (5/18/2011).

[4]John Hart, *Fertilizer and Lime Materials,* Oregon State University, Fertilizer Guide, FG52(August 1990): 3-4.

[5] NCSU courses – soil lectures

[6] Brady, N. and Weil, R. The Nature and Properties of Soils. 13th ed. 2002

[7] USDA - soils.usda.gov/technical/technotes/note8

[8] Dr. Hans-Siegfired Grunwaldt - Assessment of the Effectiveness of Carbonate Lime Materials (presentation Portland, OR September 16, 2011)